Tonsil volume, tonsil grade and obstructive sleep apnea: is there any meaningful correlation?

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OBJECTIVES: The aims of this study were to evaluate the correlation between oropharyngeal examination and objective palatine tonsil volume in snoring adults and verify the influence of the oropharyngeal anatomy, body mass index, age, and severity of obstructive sleep apnea on actual tonsil volume. In addition, we aimed to assess the influence of tonsil size on obstructive sleep apnea in adults.

INTRODUCTION: Pharyngeal wall geometry is often altered in adults who have obstructive sleep apnea, and this might influence the findings of the oropharyngeal examination that, in turn, are the key factors when considering surgical management for this condition. Furthermore, the correlation between the actual tonsil volume and the severity of obstructive sleep apnea in adults is currently unknown.

METHODS: We prospectively studied 130 patients with obstructive sleep apnea or primary snoring who underwent pharyngeal surgery with intraoperative measurement of tonsil volume. We compared tonsil volume with preoperative polysomnography, oropharyngeal examination, and anthropometric data.

RESULTS: We found a significant correlation between actual tonsil volume and subjective tonsil grade. We also found a significant correlation between tonsil volume and the apnea-hypopnea index. Using a multivariate linear regression model, tonsil volume was found to be significantly correlated with age, body mass index, and oropharyngeal examination, but not with polysomnography. Clinically, only the rare tonsil grade IV was indicative of more severe obstructive sleep apnea.

CONCLUSIONS: There is a strong correlation between clinical tonsil grade and objective tonsil volume in snoring adults, and this correlation exists regardless of the presence or severity of obstructive sleep apnea. Pharyngeal tissue volume likely reflects the body mass index rather than obstructive sleep apnea severity.

KEYWORDS: Oropharyngeal Examination; Sleep Apnea; Tonsil.

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INTRODUCTION

The role of thickened and exceedingly collapsible lateral pharyngeal walls in the pathophysiology of obstructive sleep apnea (OSA) is well recognized in adults.[1-3] The tonsils notwithstanding, narrowing of the lateral pharyngeal walls is associated with OSA in males.[2] In the pathogenesis of OSA, the influence of each component of the lateral pharyngeal wall, including fat tissue, muscles, tonsils, and vessels, is currently under investigation. Volumetric analysis of these components is usually performed with imaging examinations; however, it can be difficult to adequately distinguish between lymphoid tissue and muscle.

An oropharyngeal examination, including a subjective evaluation of tonsil size, is a simple task for a general physician. However, tonsil evaluation is based on the free pharyngeal airway space rather than the tonsil's volume itself, and theoretically, this evaluation might be influenced by structural variations in the components of the lateral pharyngeal wall. In a recent study of children, a good correlation was observed between subjective tonsil size and objective tonsil volume.[4] To our knowledge, this association has never been investigated in adults.

The purpose of this study was to evaluate the correlation between subjective measurements and objective palatine tonsil volume in adults and to verify the influence of the oropharyngeal anatomy, body mass index, age, and the severity of OSA on actual tonsil volume. In addition, we assessed the influence of tonsil size on OSA in adults.

PATIENTS AND METHODS

Data were collected prospectively for 130 consecutive patients who underwent pharyngeal surgery to treat simple snoring or OSA from 2001 through 2008 at two institutions. The study was approved by the Ethics Committees of both institutions and registered at the Brazilian National Committee of Ethics (CONEP) with the number NCT 01022320. We included patients who had both palatine tonsils removed during surgery and for whom the following information was available: intraoperative measurement of tonsil volume, preoperative oropharyngeal examination, full-night polysomnography, Epworth sleepiness scale, body mass index (BMI, in km/m^2) and a subjective evaluation of snoring on a scale from 1 (irrelevant) to 10 (worst possible). All of the histories, physical examinations and surgeries were performed by the same examiner. The surgery performed was either a lateral pharyngoplasty[5] (n = 119) or uvulopalatopharyngoplasty (n = 11), always with cold dissection tonsillectomy. The volume of the removed tonsils was assessed by liquid displacement.

Otorhinolaryngologic Physical Examination

The tonsils were subjectively measured using a grading system. In grade I, the tonsils were hidden in the tonsillar fossa and were barely visible behind the anterior pillars. In grade II, the tonsils were visible behind the anterior pillars and occupied up to 50% of the pharyngeal space (the distance between the medial borders of the anterior pillars). In grade III, the tonsils occupied between 50 and 75% of the pharyngeal space. In grade IV, the tonsils occupied more than 75% of the pharyngeal space.

To evaluate the palate-tongue position, we used a modification of Mallampati's technique,[6] with the tongue kept in place without the use of a tongue depressor. In grade 1, the tonsils, pillars, pharynx, and soft palate were clearly visible. In grade 2, the uvula and only the upper part of the pillars and tonsils were visible between the palate and the tongue. In grade 3, only the soft and hard palate were visible, whereas the tonsils, pillars, pharynx and base of the uvula were hidden behind the tongue. In grade 4, only the hard palate was visible.

The combination of the palate-tongue position and tonsil size forms the Friedman staging system,[7] which is an anatomical classification that is used for selecting cases for uvulopalatopharyngoplasty. Stage 1 corresponds to palate grade 1 or 2 with tonsil grade III or IV. In stage 2, the palate grade is 1 or 2 with a tonsil grade I or II or a palate grade 3 or 4 with a tonsil grade III or IV. Stage 3 corresponds to palate grade 3 or 4 with tonsil grade I or II. The success of uvulopalatopharyngoplasty markedly decreases with an increase in Friedman stage from 1 to 3.[7,8] Stage 4 corresponds to cases with a BMI that is higher than 40 kg/m^2 or with gross craniofacial abnormalities and is usually not suitable for pharyngeal surgeries.

Polysomnography

Each subject underwent an overnight polysomnography in a sleep center in a standard fashion with a test time of seven to eight hours. The polysomnograms were scored according to Rechtschaffen and Kales.[9] Respiratory event scoring was based on the American Academy of Sleep Medicine 1999 criteria[10] as follows: apnea, an absence of airflow for at least 10 seconds; hypopnea, a reduction (for at least 10 seconds) by more than 50% of the basal ventilatory value or a reduction by 50% or less associated with either a decrease in oxyhemoglobin saturation of more than 3% or an arousal. The variables that were evaluated were the apnea-hypopnea index (AHI) and the lowest oxyhemoglobin saturation ($LSaO_2$). With respect to the severity of the disease, the patients were classified into four groups: simple snoring (AHI≤5) or mild (5<AHI≤15), moderate (15<AHI≤30) or severe (AHI>30) OSA.

Statistical Analysis

To compare the groups with different OSA severities with respect to the variables studied, we used an analysis of variance (ANOVA) and the Fisher's exact test. Correlations between tonsil volume and the other variables were determined using the Spearman's correlation test and an ANOVA. We performed post-hoc comparisons using the Tukey and Dunnett's tests. The influence of the variables that were studied on the volume of the tonsils was analyzed using a model of multivariate linear regression. An evaluation of a possible outlier influence was also performed. Differences with a *p*-value of less than 0.05 were considered significant. Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) software version 11.0 for Windows.

RESULTS

The clinical characteristics of the 130 patients in this study are presented in Table 1. The cohort included 92 men (70.8%) and 38 women (29.2%) with a combined mean ± SD age of 44.5 ± 11.4 (men, 42.1; women, 50.5) (range 19 – 70) years and a mean BMI of 29.0 ± 3.1 (range 22.5 – 37.0) kg/m^2. With respect to OSA severity, 6.2% had simple snoring, 22.3% had mild OSA, 31.5% had moderate OSA, and 40% had severe OSA. There were significant differences between the severity groups with respect to BMI (severe>mild; severe>moderate). However, there were no significant differences between the groups with respect to tonsil grade ($p = 0.56$, Figure 1), Mallampati grade ($p = 0.36$), Friedman stage ($p = 0.59$), or gender ($p = 0.18$).

The oropharyngeal examination of the tonsils revealed that 39.2% of the subjects had grade I, 43.1% had grade II, 16.2% had grade III and 1.5% had grade IV tonsils. A Mallampati grade of 1, 2, 3 or 4 occurred in 13.8, 32.3, 48.5, and 5.4% of the subjects, respectively. According to the Friedman staging system, 10.8% of the cases were classified as Friedman stage 1, 41.5% as stage 2 and 47.7% as stage 3.

A univariate analysis of tonsil volume revealed that this volume was significantly associated with tonsil grade (grade I<II<III, $p = 0.005$, Figure 2) and Friedman stage (volume in stage 1>2>3, $p < 0.001$); however, there was no association with the Mallampati grade ($p = 0.11$). There was also a positive correlation between tonsil volume and both AHI (s = 0.18, $p = 0.04$) and the Epworth scale (s = 0.19, $p = 0.04$) as well as a negative correlation with age (s = −0.45, $p < 0.001$). Tonsil volume was not significantly correlated with any other variables, including BMI (s = 0.15, $p = 0.09$), snoring scale (s = 0.09; $p = 0.34$) or $LSaO_2$ (s = −0.07, $p = 0.44$). Tonsil volume ($p = 0.053$, Figure 3), but not tonsil grade ($p = 0.56$), had a tendency to correlate with OSA rank of severity. There were no significant differences in mean AHI between patients with grade I (30.5), II (29.6) or III (38.2) tonsils. Patients with grade IV tonsils had a higher

Table 1 - Clinical data of the studied groups (mean).

Parameter	Simple snoring (n = 8)	Mild OSA (n = 29)	Moderate OSA (n = 41)	Severe OSA (n = 52)	*p*-value
Age (years)	43.1	41.8	47.4	44.0	.21
BMI (kg/m^2)	28.9	27.0	28.4	30.5	<0.001*
AHI	3.1	10.2	22.1	57.6	<0.001*
LSaO$_2$ (%)	87.3	87.3	82.7	74.7	<0.001*
Epworth sleepiness scale	14.0	11.8	13.1	13.7	0.58
Snoring scale	9.6	9.4	9.2	9.3	0.82
Volume of the tonsils (ml)	5.4	5.6	5.3	6.8	0.053

*Intergroup significant difference ($p<0.05$).
OSA = obstructive sleep apnea; BMI = body mass index; AHI = apnea-hypopnea index; LSaO$_2$ = lowest oxyhemoglobin saturation.

AHI (mean, 103.2) than those with grade I ($p = 0.01$), II ($p = 0.01$) or III ($p = 0.03$).

Using the multiple linear regression model, a multivariate analysis of the relationship between tonsil volume and the other variables revealed that tonsil volume was significantly correlated with age ($p<0.001$), BMI ($p = 0.004$), tonsil grade ($p<0.001$), Mallampati grade ($p = 0.006$) and Friedman stage ($p = 0.028$), but not with polysomnography. According to the model, tonsil volume can be expressed by the equation:

Volume = 1.31 − (0.07*Age) + (0.17*BMI) + (1.92*Tonsil grade) + (0.99*Mallampati) − (1.2*Friedman)

DISCUSSION

Measuring tonsil volume in surgically removed specimens is likely the most accurate method for quantifying that volume. In this study, we found that in adults with snoring and OSA, the clinical tonsil grade correlated well with the actual volume of this tissue, despite large variations in age and/or BMI. For example, according to our equation, an increase of one grade in the tonsils of a patient would yield an increase of 1.92 ml in tonsil volume, whereas a relatively large difference in BMI of 10 kg/m^2 between two patients of the same age, palate position and tonsil grade would yield a difference of 1.70 ml in tonsil volume. Additionally, our measurements show that grade III tonsils are significantly larger than grade II tonsils, which are larger than grade I tonsils. We only had two cases of the rare tonsil grade IV. To our knowledge, this is the most discriminative grading system for palatine tonsils that has been correlated with actual tonsil volume in adults.

What is the relevance of this correlation between subjective and objective tonsil volume in patients with OSA? The grade of the palatine tonsils is usually defined by the volume of space that is claimed by the tonsils in the pharyngeal airway. Among several anatomic factors that are involved in the pathogenesis of OSA, most patients present with either an excess amount of soft tissue or an underdeveloped bony skeleton that leads to the narrowing of the pharynx.[11] The narrow lateral pharyngeal wall with which these patients present is either the result of larger lateral fat pads, muscle thickening, or tissue edema, which may be due to cervical vascular congestion.[1,3,12,13] Each of these factors may displace the palatine tonsils towards the pharyngeal lumen, leading to an overestimation of their real size. Our data revealed that this is not the case: following a major increase of more than 11 kg/m^2 in BMI, the same tonsil volume would be clinically graded as smaller, not bigger. Therefore, the clinical tonsil grade is a simple, reliable and independent predictor of actual tonsil volume in patients with OSA.

Our multivariate equation demonstrates that tonsil volume decreases as age advances, which is expected given the tissue's natural involution, and with increasing Friedman stage, which is also expected because this parameter usually implies a lower tonsil stage and therefore less tonsil volume. In contrast, tonsil volume increases as BMI and the Mallampati score increase, which implies a more crowded

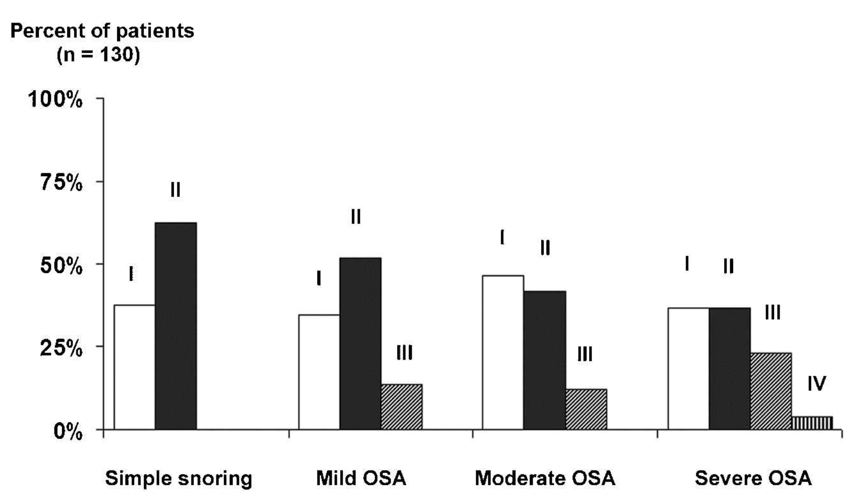

Figure 1 - Distribution of the observed tonsil grade (I, II, III or IV) among the various obstructive sleep apnea (OSA) severities ($p = 0.56$).

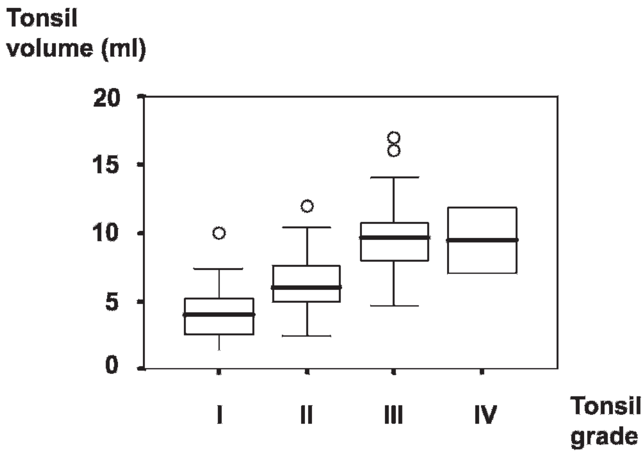

Figure 2 - Box plot of tonsil volume versus tonsil grade (I<II<III, $p = 0.005$). Open circles indicate the outliers.

upper airway. Therefore, as with tongue volume,[14] pharyngeal tissues also appear to be proportional to body size among both heavy snorers and OSA patients, thereby suggesting a secondary role of anatomy in OSA. It is interesting to note that the effect of uvulopalatopharyngoplasty would be noticeable in patients who do not follow this trend and have a disproportionate anatomy, for example, in patients with large tonsils and a low Mallampati score, as opposed to patients with large tonsils and a high Mallampati score.[7,8]

The second issue we investigated was the relationship between tonsil size and OSA severity. None of the clinical oropharyngeal data (i.e., tonsil grade, Mallampati grade or Friedman stage) was correlated with the severity rank of OSA. In contrast, tonsil volume was correlated with AHI and had a tendency to correlate with the severity rank of OSA ($p = 0.053$). Other groups have studied the relationship between clinical tonsil evaluation and AHI and reported a tendency approaching significance[15] or a

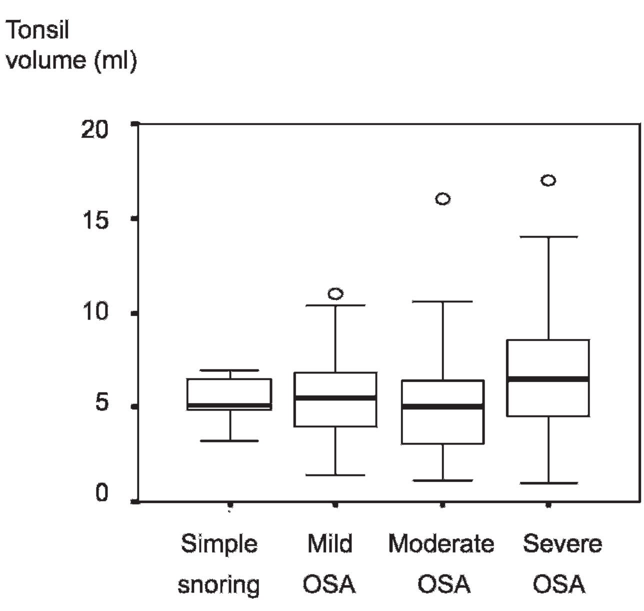

Figure 3 - Box plot of tonsil volume versus the severity of obstructive sleep apnea (OSA) ($p = 0.053$). Open circles indicate the outliers.

significant relationship between these parameters.[6] More important, these studies showed that a combination of increased oropharyngeal tissues served as a much stronger predictor of OSA than isolated upper airway findings. Because our data show that a higher BMI is associated with increased pharyngeal tissues, we suspect that such combinations simply predict the BMI, which is the strongest predictor of the presence of OSA. Thus, one should weight other anthropometric features before defining the role of large tonsils in OSA. In addition, we believe that future research in this field should investigate correlations between anthropometric features and the severity rank of OSA rather than solely with AHI because that rank would be more informative for the clinician.

Clearly, the removal of extremely large tonsils (grade IV) is indicated in the management of adult OSA and produces a highly positive impact on the patient's quality of life.[16-18] Our rare cases with tonsil grade IV had the highest AHI. These cases aside, the impact of tonsils that extend beyond the tonsillar bed on OSA is controversial. Some authors classify all of these cases as large tonsils (grade III or IV), which implies possible surgical intervention;[8] however, our grading system, which is easy to learn and implement, may identify tonsils that extend beyond the tonsillar bed as grade II, III and IV, and only grade IV tonsils have a definite impact on OSA severity.

There was a potential bias in our study because all of our cases underwent pharyngeal surgery for snoring or OSA and because we excluded cases with a BMI over 35 kg/m^2 or with a gross maxillary or mandible deformity. In theory, this bias would have restricted the oropharyngeal features of our subjects to a particular subtype, because the success of traditional uvulopalatopharyngoplasty or tonsillectomy in OSA treatment is largely related to the presence of large tonsils.[7,8,16-18] In contrast, the majority of our patients (91.5%) underwent a lateral pharyngoplasty procedure[5], which is based on the reconstruction of the lateral pharyngeal wall, and has an improved outcome over uvulopalatopharyngoplasty regardless of tonsil volume.[19] Thus, we were able to include the 82.3% of cases with tonsil grades I or II, which appear to be similar to the general OSA population.[15]

We also recognize that we cannot use our data as a screen for OSA because we did not include a control group of non-snoring, non-OSA subjects. All of our patients complained of heavy snoring that significantly impacted their social life. Even our simple snoring group had excess daytime somnolence (with a mean Epworth scale score of 14), which we attributed to increased upper airway resistance because it improved after surgery. Consistent with reports by other groups, we believe that heavy snoring and OSA represent a progressive disease, and this progression depends more heavily on functional factors than anatomical factors and may also be influenced by the use of some drugs.[20,21] The mere presence of an obstacle within the upper airway is not sufficient to produce OSA,[22] and even in children, for whom the influence of anatomical factors is more definitive for OSA, tonsil volume does not correlate with AHI.[4]

CONCLUSIONS

In adult snorers and OSA patients, there is a good correlation between clinical tonsil grade and objective tonsil volume. The clinical ability to infer tonsil volume is not impaired by possible changes in pharyngeal geometry that are related to OSA. Although tonsil volume correlates with AHI, from a clinical perspective, only tonsil grade IV predicts severe OSA. Pharyngeal tissue volume likely reflects body mass index rather than OSA.

REFERENCES

1. Schwab RJ, Pasirstein M, Pierson R, Mackley A, Hachadoorian R, Arens R, et al. Identification of upper airway anatomic risk factors for obstructive sleep apnea with volumetric magnetic resonance imaging. Am J Respir Crit Care Med. 2003;168:522-30, doi: 10.1164/rccm.200208-866OC.
2. Schellenberg JB, Maislin G, Schwab RJ. Physical findings and the risk for obstructive sleep apnea. Am J Respir Crit Care Med. 2000;162:740-8.
3. Schwab RJ, Gupta KB, Gefter WB, Metzger LJ, Hoffman EA, Pack AI. Upper airway and soft tissue anatomy in normal subjects and patients with sleep-disorders breathing: significance of the lateral pharyngeal walls. Am J Respir Crit Care Med. 1995;152:1673-89.
4. Howard NS, Brietzke SE. Pediatric tonsil size: Objective vs subjective measurements correlated to overnight polysomnogram. Otolaryngol Head Neck Surg. 2009;140:675-81, doi: 10.1016/j.otohns.2009.01.008.
5. Cahali MB. Lateral pharyngoplasty: a new treatment for obstructive sleep apnea hypopnea syndrome. Laryngoscope. 2003;113:1961-8, doi: 10.1097/00005537-200311000-00020.
6. Friedman M, Tanyeri H, La Rosa M, Landsberg R, Vaidyanathan KMS, Pieri S, et al. Clinical predictors of obstructive sleep apnea. Laryngoscope. 1999;109:1901-7, doi: 10.1097/00005537-199912000-00002.
7. Friedman M, Ibrahim H, Bass L. Clinical staging for sleep disordered breathing. Otolaryngol Head Neck Surg. 2002;127:13–21, doi: 10.1067/mhn.2002.126477.
8. Friedman M, Ibrahim H, Joseph NJ. Staging of obstructive sleep apnea/hypopnea syndrome: a guide to appropriate treatment. Laryngoscope. 2004;114:454-9, doi: 10.1097/00005537-200403000-00013.
9. Rechtschaffen A, Kales A. A manual of standardized terminology, techniques and scoring system of sleep stages of human subjects. Los Angeles: Brain Research Institute UCLA, 1968.
10. American Academy of Sleep Medicine. Sleep-related breathing disorders in adults: recommendations for syndrome definition and measurement techniques in clinical research. Sleep. 1999;22:667-89.
11. Ryan CM, Bradley TD. Pathogenesis of obstructive sleep apnea. J Appl Physiol. 2005;99:2440-50, doi: 10.1152/japplphysiol.00772.2005.
12. Anastassov GE, Trieger N. Edema in the upper airway in patients with obstrutictive sleep apnea syndrome. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1998;86:644-7, doi: 10.1016/S1079-2104(98)90197-4.
13. Bradley TD, Rutherford R, Grossman RF, Lue F, Zamel N, Moldofsky H, et al. Role of daytime hypoxemia in the pathogenesis of right heart failure in the obstructive sleep apnea syndrome. Am Rev Respir Dis. 1985;131:835–9.
14. Do KL, Ferreyra H, Healy JF, Davidson TM. Does tongue size differ between patients with and without sleep-disordered breathing? Laryngoscope. 2000;110:1552-5, doi: 10.1097/00005537-200009000-00027.
15. Zonato AI, BIttencourt LR, Martinho FL, Júnior JFS, Gregório LC, Tufik S. Association of systematic head and neck physical examination with obstructive sleep apnea syndrome. Laryngoscope. 2003;113:973-80, doi: 10.1097/00005537-200306000-00011.
16. Nakata S, Noda A, Yanagi E, Suzuki K, Yamamoto H, Nakashima T. Tonsil size and body mass index are important factors for efficacy of simple tonsillectomy in obstructive sleep apnea. Clin Otolaryngol. 2006;31:41-5, doi: 10.1111/j.1749-4486.2006.01130.x.
17. Martinho FL, Zonato AI, Bittencourt LR, Soares MCM, Silva RFN, Gregório LC, et al. Obese obstructive sleep apnea patients with tonsil hypertrophy submitted to tonsillectomy. Braz J Med Biol Res. 2006;39:1137-42, doi: 10.1590/S0100-879X2006000800017.
18. Verse T, Kroker BA, Pirsig W, Brosch S. Tonsillectomy as a treatment of obstructive sleep apnea in adults with tonsillar hypertrophy. Laryngoscope. 2000;110:1556–9, doi: 10.1097/00005537-200009000-00029.
19. Cahali MB, Formigoni GGS, Gebrim EMMS, Miziara ID. Lateral pharyngoplasty versus uvulopalatopharyngoplasty: a clinical, polysomnographic and computed tomography measurement comparison. Sleep. 2004;27:942-50.
20. Friberg D. Heavy snorer's disease: a progressive local neuropathy. Acta Otolaryngol. 1999;119:925-33, doi: 10.1080/00016489950180306.
21. Neves C, Tufik S, Chediek F, Poyares D, Cintra F, Roizenblatt M, et al. Effects of sildenafil on autonomic nervous function during sleep in obstructive sleep apnea. Clinics. 2010;65:393-400, doi: 10.1590/S1807-59322010000400008.
22. Strohl K, Redline S. State-of-the-art: recognition of sleep apnea. Am J Respir Crit Care Med. 1996;154:279-89.